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are not shut up to this conclusion. There are various other ways in which pebbles might be introduced into eolian sand. The burrowing animals and the growth and decay of the roots of trees might introduce relics and stones from the top, if they were left by men on the surface. Relics of modern civilization, bits of coal, pieces of brick, etc., were found in the sand down to a maximum depth of seventeen inches. The uprooting of considerable trees might bring up gravel stones of considerable size from depths of several feet into the surface material. If forest trees were ever upturned by winds in this locality they could not fail to bring up pebbles into the sand above the gravel. The breaks in the streaks already referred to might find explanation in such disturbances. In view of these possibilities the presence of the pebbles in the sand cannot be asserted to prove that it is not of wind origin.* Finally, it is believed that no unqualified conclusion concerning the origin of the relic-bearing sand is warranted. It may be of aqueous origin, dating from the close of the last glacial epoch; it may be of aqueous origin of later age, for sea water probably covered the region at the close of the last glacial epoch or later; and it may be eolian, dating from a time long subsequent to the deposition of the sand and gravel of the plain.

Whatever its origin, it may safely be said that the surface material down to the lowest depth at which the relics have been found has been so disarranged that no affirmation can be made concerning the origin of the pebbles and relics it contains. It is all within the zone of active weathering and surface disturbance. If the finds were

fossils, in the usual sense of the term, it is certain that geologists would not feel warranted in attaching much importance to them.

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SANARELLI'S WORK UPON YELLOW FEVER.

At the request of the editor of SCIENCE I append a brief *résumé* of Sanarelli's recent papers upon yellow fever.*

The most important study of yellow fever that appeared before Sanarelli's investigations were undertaken was that made in 1888-9 by Dr. Sternberg, whose researches led to an essentially negative result. Upon only one microorganism found by him in the course of his thoroughgoing investigations did any degree of suspicion fall, and the evidence against this germ was summed up by Sternberg as follows:

"Among the facultative anaërobics is one—my *Bacillus X*—which has been isolated by the culture method in a considerable number of cases and may have been present in all. This bacillus has not been encountered in the comparative experiments made. It is very pathogenic for rabbits when injected into the cavity of the abdomen.

"It is possible that this bacillus is concerned in the etiology of yellow fever, but no satisfactory evidence that this is the case has been obtained by experiments on the lower animals, and it has not been found in such numbers as to warrant the inference that it is the veritable infectious agent.

"All other microorganisms obtained in pure cultures from yellow fever cadavers appear to be excluded, either by having been identified with known species, or by having been found in comparative researches made outside of the area of yellow fever prevalence, or by the fact that they have

* My co-laborer in New Jersey, Mr. George N. Knapp, visited the locality where the relics are found in June, and reached the conclusion that the sands in question are eolian. No one else has more intimate familiarity with these sands than he.

* *Annales de l'Institut Pasteur*, June, September, October, 1897.

been found only in small numbers and in a limited number of cases."

Sternberg has recently called attention* to the close similarity between his description of the 'Bacillus X' mentioned in the above quotation and the description of '*B. icteroides*' given by Sanarelli, and makes out a strong case for the view that the two are identical.

Sanarelli began his work in February, 1896, shortly after his appointment as Director of the Institute of Experimental Hygiene at the University of Montevideo. In 7 out of 12 autopsies made by him upon the bodies of victims of yellow fever there was found a specific bacillus (*B. icteroides*) which he regarded as hitherto undescribed. The reasons assigned for the failure of himself and others to isolate this microbe in all cases of yellow fever are: 1. That *B. icteroides* multiplies in the human body only to a limited extent, the complete and characteristic effects of the disease being produced by only a very small quantity of toxin. 2. That this toxin, whether directly or indirectly, facilitates to a remarkable degree secondary infection of all kinds. These secondary infections with the colon bacillus, streptococcus, staphylococcus, etc., may of themselves be fatal to the patient, and Sanarelli believes that the fatal termination or several cases observed by him is to be explained in this way. 3. That these mixed infections not only lead to the speedy disappearance of the specific microbe, but also frequently end by transforming the organism of the patient into a culture medium for almost all kinds of intestinal bacteria.

The bacteriological complications arising from these facts enhance considerably the technical difficulties of isolating the specific bacillus. Sanarelli did not succeed in finding the germ in the gastro-intestinal contents and is inclined to doubt if it usually occurs there at all; he did, however, dis-

cover it in the circulating blood and in some of the important organs of the body, notably in the liver. He refers to the prevailing belief that the infectious material in yellow fever is localized in the stomach and is to be sought for especially in the black vomit, but prefers, for his part, to regard the gastric disturbances as due to the selective action of the toxin, a view similar, it will be remembered, to his interpretation of the intestinal lesions of typhoid fever.

Bacillus icteroides grows readily upon the ordinary nutritive media, fluid and solid. It is described as a rod about 2μ – 4μ in length, with rounded ends, often joined in pairs, and staining readily with the ordinary aniline dyes, but decolorized by Gram's method. The colonies upon a gelatin plate resemble in some particulars those of the colon bacillus, but never show any trace of the chestnut color developed in cultures of the latter; so-called pleomorphism of the colonies is, however, marked.

Contrary to what is true of most of the known pathogenic microbes, the growth of *B. icteroides* upon agar is especially characteristic and furnishes a diagnostic test of the first importance. If the cultures are allowed to develop in the incubator at 37° for from 12 to 24 hours, and are then transferred to a temperature of from 20° to 28° , there is produced what Sanarelli regards as a highly characteristic appearance. The growth at the lower temperature forms a sort of halo around the portion of the colony developed in the incubator, and this appearance is so singular that according to Sanarelli a mere superficial inspection suffices to distinguish immediately, and with the naked eye, a colony of *B. icteroides* in the midst of all other bacterial colonies yet described. As the growth goes on, an effect is produced as if a layer of opaque paraffin had been poured over the agar and then impressions made in it with a small circular seal, the imprints of this seal corresponding with

* *Centralbl. f. Bakt.* I. Abth. XXII., Nos. 6 and 7.

the original transparent colonies grown in the incubator. The final aspect of the culture is compared to a miniature archipelago in which the islets would be represented by the colonies first developed, and the surface of the water by the layer subsequently formed at the lower temperature.

Blood-serum and potato proved themselves to be rather unsuitable media for *B. icteroides*. In milk the germ grows readily, but without producing coagulation. The most favorable fluid medium tested by Sanarelli was beef broth containing lactose and calcium carbonate.

The germ is pathogenic for most of the domestic animals. Mice, guinea-pigs and rabbits succumb readily to inoculation with a pure culture. The rabbit is considered as the most favorable subject for experimental inoculation, and possesses notable advantages over the guinea-pig both in susceptibility and in the regularity and constancy of symptoms and death. The dog, however, presents the most instructive instance of close analogy with the disease yellow fever as it manifests itself in man. Both in the symptoms and in the anatomical lesions Sanarelli was able to trace a correspondence at once constant and precise. As is the case in man, the liver and the kidneys are the organs especially attacked; secondary infections with the streptococcus and colon bacillus sometimes occur.

In the second memoir Sanarelli details the results of his experiments with the yellow fever toxin. Cultures of the germ 15-20 days old, made in ordinary peptonized meat broth and filtered through a Pasteur-Chamberland tube, afforded him a potent toxin. The toxin thus prepared, when injected into the bodies of susceptible animals, produced substantially the same symptoms as inoculation with the specific bacillus. In the dog, particularly, inoculation with the germ-free toxin set in motion the same train of specific symptoms and caused the same

pathological changes in the tissues. "The toxin of yellow fever is an exceedingly powerful cellular poison comparable solely, in some points, to the diphtheria toxin. Its contact with the tissue elements of the animal organism, especially the higher species, determines, like that of the diphtheria toxin, a violent irritation, followed by retrogressive processes which always end in the necrosis and fatty degeneration of the protoplasm."

Some very interesting experiments bearing on the question of mixed infection are next described. When *B. icteroides* is sown upon culture media on which, respectively, the colon bacillus, streptococcus and proteus have been previously grown, it is found that the growth of the former is distinctly inhibited by the presence of the soluble products of the other microbes. The latter, on the contrary, grow excellently in a medium previously inhabited by *B. icteroides*, and are only slightly incommoded by the presence of the soluble products of one another, the products of the proteus bacillus seeming most injurious to all concerned. A similar result was revealed by a study of the 'vital antagonism' of *B. icteroides* and the microbes concerned in the secondary infections. Both *streptococcus pyog.* and *staphylococcus pyog. au.* speedily gain the upper hand over *B. icteroides*, and a similar, though less marked superiority, is manifested by the colon bacillus. These facts certainly shed much light on the difficulty of demonstrating the presence of the yellow fever germ in the bodies of victims of the disease, and go far to explain the negative result reached by many observers.

In an attempt to account for the important part played by maritime commerce in the diffusion of yellow fever Sanarelli records a curiously significant observation. It was noticed that gelatin plates sown with *B. icteroides* sometimes remained without development, although agar plates sown at the same time evinced abundant growth. But

if a colony of mould made its appearance on the gelatin plate, colonies of *B. icteroides* immediately sprang up around it. After some days the colonies of *B. icteroides* form a sort of constellation around the mould, the most abundant development taking place in the immediate neighborhood of the latter. This observation was experimentally verified with six species of moulds (not named) 'accidentally isolated' in the laboratory, all of which proved themselves, although in different degrees, capable of favoring the revivification and multiplication of the yellow fever germ. To this singular symbiotic relation Sanarelli is inclined to attribute the ready domiciling of the disease on shipboard and its connection with warmth, moisture and darkness, conditions which, by directly favoring the germination of moulds, indirectly favor *B. icteroides*.

In some brief notes upon the resistance of the germ to physical and chemical agents it is stated that, by exposure of broth cultures to 55°, the germ is killed in about twenty minutes, and that it is instantly destroyed by a temperature of 65°. Dry heat at 110°-125° is speedily fatal, and exposure for one hour and ten minutes at 100° also suffices to destroy vitality. Considerable resistance is shown to desiccation, a result of evident practical importance. In sea water the bacillus shows great vitality, surviving in the sterilized brackish water of the La Plata for upwards of ninety days.

Sanarelli's third memoir is devoted to a consideration of immunity and serum therapy. The serum obtained from the bodies of yellow fever victims causes agglutination of *B. icteroides*, although the intensity of the reaction is said to be quite variable. This serum does not exert any protective power in inoculated animals. Serum from a convalescent provoked a tardy agglutination and manifested a slight preventive power.

An attack of yellow fever in man confers

some degree of immunity against a second attack, and hence it would seem as if it might be possible in some way to vaccinate animals against the disease. Attempts to produce immunity in the rabbit failed on account of the excessive sensibility of this animal to the yellow fever virus, and the same difficulty prevented the use of the goat and the sheep. The work upon immunization was mainly limited, therefore, to experiments upon the guinea-pig, the dog and the horse. In all these animals immunization is an unusually difficult and laborious task. While it is possible to immunize a guinea-pig against cholera or typhoid fever in from two to three months, it needs six to seven months of assiduous and delicate work to vaccinate this animal against yellow fever. Dogs may be immunized somewhat more readily, but never become tolerant of large doses of toxin. Horses are treated first with small doses (5-10cc.) of a filtered culture of the germ injected subcutaneously, followed with intravenous injections. After two months of treatment with filtered cultures the more potent doses of cultures sterilized by ether may be used; it is not until five to six months after the beginning of the treatment that the first injection of a living culture may be safely hazarded. During this process of immunization many of the animals die and all are profoundly affected.

The serum of animals immunized in this way is endowed with protective and curative properties and can be used with success in animal experiments. A single instance may serve to illustrate the results obtained by this procedure. A horse under treatment for the space of nine months received subcutaneously during this period 29cc. of filtered cultures and 350cc. of cultures sterilized with ether, and intravenously 2640cc. of sterilized cultures, 345cc. of living broth cultures and 19cc. of an agar culture. The serum (0.5cc.) from this

animal, when injected into a guinea-pig 24 hours before inoculation with several times the fatal dose, conferred immunity; 2cc. proved potent enough to save the lives of guinea-pigs when injected 48 hours after inoculation.

Sanarelli's work upon immunization was still in progress when the third memoir was written, and the outcome of his projected experiments in serum-therapy will be awaited with much interest.

EDWIN O. JORDAN.

LUDWIG RÜTIMEYER.

On the 25th of November, 1895, died at Basle Ludwig Rüttimeyer, the last survivor of a long series of Swiss naturalists, the representatives of the classic period of natural science in this country. Now, two years after the death of this distinguished naturalist, his miscellaneous papers appear in a form capable of attracting the attention of the scientific world.* Rüttimeyer's numerous publications, which for a long time chiefly adorned the 'Abhandlungen der schweizerischen palæontologischen Gesellschaft' and the 'Denkschriften der schweizerischen naturforschenden Gesellschaft,' could not be reproduced, but the smaller occasional lectures and writings, which, owing to the astonishing universality of Rüttimeyer's researches and studies, deal with questions of zoology and anthropology as well as of geology and geography, are here collected in two volumes. It is well known what a high position the leader of European paleontology, von Zittel, has assigned, for example, to Rüttimeyer's paper on the geographical and geological distribution of animals. Whoever shall read this and the similar papers made accessible by this edition will be surprised by the perspicacity of the conclusions and the abundance of openings in every direction of

* 'Gesammelte Schriften.' Basle, Georg et Cie. 1898.

natural philosophy, the exceeding originality and the immense knowledge of details which characterized the man, to whom in the last decades, along with Sir Richard Owen, Vertebrate Paleontology in Europe is most indebted. Among the fundamental questions of zoology we find treated the principles of natural history, the boundaries of animal life, the phylogeny of the vertebrate skeleton, the changes in animal life in Switzerland since the presence of man, the modality of progress in the organic world, general considerations on the seccionic structure of Europe, history of glacier studies in Switzerland, three essays on the Bretagne and addresses in the memory of L. Agassiz, Ch. Darwin, P. Merian and B. Studer, who were in intimate relations with Rüttimeyer. The first volume is introduced by an autobiographical sketch, which may give to American naturalists an idea of the development, the many suggestions and difficulties of a Swiss who devoted his life to natural philosophy.

RUD. BURCKHARDT.

BASEL, December 1, 1897.

CURRENT NOTES ON PHYSIOGRAPHY. *

THE GLACIAL LAKE AGASSIZ.

As the Monographs by Gilbert and Russell on the extinct Lakes Bonneville and Lahontan are the classics with regard to basins from which former bodies of water have been withdrawn by evaporation, so

* In SCIENCE for December 3d it was implied that the recent report of the Maryland Geological Survey had neglected possible relations with the schools of the State and devoted its physiographic studies to the interests of 'those who may seek a home in Maryland.' This error was due to my eye having caught the heading 'Study of the Pysiographic Features of the State' (p. 40), in which only the immigrant is referred to as taking advantage of the results; while I failed to note, under the heading 'Preparation of Final Reports,' a very explicit mention of their educational significance. "It is most desirable that the youth of Maryland should grow up with a knowledge of the country in which they live, and be